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MANGANESE ORE DEPOSITS OF THE USSR

Caucasian Manganese Ore

Manganese ore containing pyrolusite with an admixture of manganite and psilomelane is mined in rich deposits in the Kvirila River valley, close to Chiatury. The chemical composition of the Chiatury ore is given in the first five columns of Table 1. Column VI of the same table gives the composition of carbonate ore recently discovered in the Chiatury region by Prof A. R. Betekhtin.

A comparison of the composition of individual components of the ore shows that the richest is psilomelane, which contains as much gangue as pyrolusite does. Analysis shows that one fourth of the manganese is in the form of oxide, while the quantity of water of hydration is not large. Water of hydration is also found in pyrolusite in the form of hydrated silica. Manganite is an ingredient which lowers the manganese content of the ore. It contains a large amount of gangue ($SiO_2 + Al_2O_3$) and up to 10 percent water of hydration. $Mn_2O_3.H_2O$ is represented in the analysis as $MnO+MnO_2+H_2O$. Bog manganese also contains these components, differing merely in the value of the coefficients of MnO, MnO_2 H_2O, as in the following formula: $m\,MnO \cdot nMnO_2 \cdot p\,H_2O$.

The amount of harmful impurities is not given in every analysis, which prevents comparison of the degree of purity of individual components of the Chiatury ore. The gangue of all the components is similar - argillaceous sand containing barium compounds, an admixture characteristic of manganese ores. The barium is indicated in three analyses of pyrolusite and manganite.

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Table 1. Analysis of Chiatury Manganese Ore
(in percent)

	Pyrolusite		Psilomelane	Manganite		Carbonate
	I	II	III	IV	V	VI
SiO_2	3.96	3.85	3.50	8.11	8.47	2.13
Al_2O_3	1.48	1.74	not indicated	2.49	2.30	2.96
Fe_2O_3	not indicated	0.61	0.70	0.99	1.64	--
FeO	none	none	none	none	none	1.96
BaO	none	1.54	not indicated	1.10	2.14	--
CaO	0.57	1.73	3.01	0.49	0.35	15.83
MgO	0.88	0.20	--	0.17	1.06	2.50
MnO	none	0.47	24.90	34.12	32.16	36.80
MnO_2	89.96	86.25	60.60	37.40	40.15	none
Alkalies	0.22	0.22	--	0.44	0.52	none
P_2O_5	not indicated	0.32	0.52	not indicated	not indicated	none
SO_3	not indicated	0.23	not indicated	not indicated	0.31	none
CO_2	none	0.63	--	none	--	36.30
H_2O (hydration)	1.81	1.85	5.53	9.92	9.96	none
H_2O (moisture)	0.87	--	--	5.10	1.00	1.82
Total	99.75	99.64	98.76	100.33	100.06	100.30
Fe	none	0.43	0.49	0.69	1.15	1.52
Mn	56.9	55.0	57.50	50.00	50.30	28.5
P	not indicated	0.14	0.23	not indicated	not indicated	--
S	not indicated	0.092	not indicated	not indicated	0.124	--

The ore is easily concentrated by washing, which removes sand and clay. In the past the ore was washed only when it was necessary to obtain high-grade pyrolusite for use as raw material in chemical plants. Manganese ore used for export was sent without concentration. Its manganese content, however, was between 48 and 52 percent. According to Clements, this ore contained 8-10 percent silica, 1-1.5 percent iron, 2 percent lime with magnesia and 0.18 percent phosphorus in a dried state. The ore arrived abroad with 6-8 percent moisture and in a more or less powdery condition, with lump ore averaging about 10 percent. In the 1930s ore washing in the Chiatury region had greatly increased, and the ore began to be shipped to consumers in two forms, ordinary and washed. The latter is at present divided into four grades depending on its manganese content.

Table 2. Grades of Washed Chiatury Ore
(in percent)

	1	2	3	4
Manganese	49-53	45-48	39-44	25-38
Silica	10-11	12-16	17-21	22-35
Moisture	8-9	9-12	12-15	15-18

In all four varieties the phosphorus does not exceed 0.20 percent and is actually never less than 0.18 percent.

In the ordinary ore, the amount of manganese varies from 25-47 percent. The ore is divided into only two grades, one containing 42-47 percent manganese, 15-18 percent silica, and 11-12 percent moisture, and the other containing 25-41 percent manganese.

The high ratio of manganese to iron in the Chiatury ore makes it possible to smelt alloys with a high manganese content. Deficiencies of the Chiatury ore are a high silica and phosphorus content and a high powdery state (90 percent fines and 10 percent lump ore). In spite of these defects, however, Chiatury ore is competing successfully on the international market with Indian and Brazilian ores.

Reserves of the Chiatury deposit are large, amounting to 146 million tons in categories A and B. Category C (probable or possible reserves) is estimated at about 30 million tons. The discovery of new deposits of carbonate ore changes this figure, but just how much is still unknown since no detailed survey of these deposits has yet been made.

In their chemical composition the carbonate ores are an isomorphic mixture of carbonates of manganese and calcium with a small admixture of carbonates of magnesium and iron. The amount of manganic carbonate in the ore varies from 35 to 73 percent; of calcium carbonate, from 15 to 35 percent. The gangue ($SiO_2 + Al_2O_3$) in the ore does not exceed 13 percent (5 percent minimum). The ore seems to be a low-grade ore containing 28.5 percent manganese (Table 1). However, when roasted, it assumes the following composition (in percent):

SiO_2	Al_2O_3	CaO	MgO	Mn	Fe
3.35	4.52	24.16	3.82	43.32	2.88

It follows from these figures that the ore is a mixture of 20 percent lime and magnesia with 80 percent self-fluxing ore containing 54 percent manganese whose oxides are intermixed with lime and are therefore in a state most advantageous for the processes of [redacted] agglomeration.

The carbonate ore, poor in manganese, may be considered limestone enriched with manganese, which can be used in blast-furnace smelting, for example, in the Dashkesan plant.

Nikopol' Manganese Ore

The Nikopol' ore is mined in the Ukraine. Mineralogically, this ore consists of pyrolusite with an admixture of psilomelane and bog manganese. In its natural state the Nikopol' ore contains a larger amount of gangue - argillaceous sand - than Caucasian ore. Its manganese content drops to 28 percent and the amount of silica rises to 42 percent. Therefore, all ore is concentrated by washing. Washed ore is divided into four grades, as follows:

Table 3. Grades of Washed Nikopol' Ore
(in percent)

	1	2	3	4
Manganese	45-51	40-44	29-39	25-28
Silica	9-15	16-24	25-37	38-43
Moisture	16	18	20	24

The chemical composition of Nikopol' ore - both natural and dressed - is shown in the first four columns of Table 4. From the table it is evident that Nikopol' ore, like Caucasian ore, gives a ratio of manganese to iron which is higher than 10. This makes it possible to smelt high-quality ferromanganese. Since the phosphorus content in Nikopol' ore varies between 0.20 and 0.27 percent, the ferroalloys smelted from it have a higher phosphorus content than those from Caucasian ores. Nevertheless, plants of the Soviet Union smelted all their ferromanganese from Nikopol' ores, and not always from first grade ore. Only third grade ore was used in smelting pig iron for steel manufacture. The best ore was exported abroad.

Table 4. Analysis of Nikopol' and Mazul'sk Manganese Ores (in percent)

	Nikopol'				Mazul'sk	
	Raw	Dressed 1st Grade	Dressed 2d Grade	Dressed 3d Grade	Rich	Average Composition
SiO_2	28.20	9.15	14.99	22.00	9.21	21.93
Al_2O_3	7.40	1.18	4.87	5.84	5.24	10.76
Fe_2O_3	1.80	1.03	4.98	2.11	7.91	23.61
BaO	--	--	--	--	3.67	--
CaO	1.18	1.01	1.80	2.78	1.73	4.31
MgO	1.12	0.11	0.28	1.87	0.31	1.37
MnO	5.39	--	--	--	3.00	0.92
MnO_2	45.74	79.37	66.88	57.38	55.80	26.71
Alkalies	--	--	--	--	0.64	--
P_2O_5	0.38	0.519	0.504	0.39	0.32	0.61
S	0.018	0.05	--	--	none	0.10
Losses during roasting	8.90	7.60	5.75	8.00	10.99	5.27
Total	100.13	100.02	100.00	100.37	98.82	95.39
Fe	1.26	0.71	3.45	1.48	5.56	16.53
Mn	33.08	50.18	42.28	35.93	37.55	17.71
P	0.166	0.226	0.22	0.17	0.14	0.266

Ural Manganese Ore

A great many deposits of manganese ore have been discovered in the Urals. None of them, however, can compare with the Sapal'sk deposit in the Iebyarhki Mountain, which for 53 years had supplied the Tagil plants with high-grade manganese ore. Existing Ural deposits are not large, and the ore has a high siliceous and low manganese content. As long as it was possible to obtain pig iron of high manganese consistency from southern blast furnaces, the Ural

manganese ores did not have to be utilized. But wartime conditions made it necessary to use the inferior Ural ores of the Polunochnoye and Urazovsk deposits.

The Polunochnoye is the largest deposit in the Northern Urals (Serov Rayon). The basic minerals of this ore are pyrolusite in the upper oxidized layer of the deposit and carbonate of iron-manganese in the lower. The gangue - and arenaceous clay - adds a great deal of silica to the ore, while the presence of pyrolusite makes it supple and powdery. The ore also contains occasional pieces of crushed carbonate.

Table 5. Chemical Analysis of Polunochnoye Ore
(in percent)

	I	II
Mn	32.31	26.50
Fe	5.92	3.12
P	0.10	0.14
S	0.07	0.12
SiO_2	27.60	35.97
Al_2O_3	5.39	5.24
CaO	1.90	1.36
MgO	1.08	1.26

Analysis No II is an average of many analyses and, very likely, closely reflects the average composition of the ore. Its manganese to iron ratio is 8.5, which enables smelting of alloys containing 78 percent ferromanganese (with a manganese assimilation coefficient of 0.7; a larger coefficient cannot be expected with a silica content as high as 36 percent). An iron content of 5.92 percent and a manganese content of 32.31 percent in analysis No I make it possible to smelt an alloy which contains only 73 percent ferromanganese.

Both analyses relate to oxidized ores; carbonate ores are of a much lower grade and their manganese content varies between 10 and 25 percent. The content of volatiles reaches 23.5 percent (only 8-15 percent in oxidized ores).

Reserves of the Polunochnoye Manganese deposit are estimated at 2.6 million tons, of which half is carbonate ore.

The Urazovsk deposit is located near the Magnitogorsk plant. It began operations very recently and is already depleted.

Kazakhstan Manganese Ores

Kazakhstan deposits were discovered recently and since 1942 the ore of these deposits has been used at the Magnitogorsk plant.

The Dzhezdinsk deposit was one of the first to come under exploitation. Its ore is a solid, firm braunite with an admixture of pyrolusite. The manganese content of the ore varies from 25 to 55 percent, the average being about 32 percent; it contains little iron and few harmful impurities.

Table 6. Chemical Analysis of Dzhezdinsk Ore
(in percent)

	I	II
Mn	41.20	36.23
Fe	2.12	2.74
P	0.123	0.146
S	0.01	0.13
SiO_2	16.54	20.19
Al_2O_3	3.84	5.10
CaO	0.62	0.94
MgO	0.37	0.35

The gangue of Dzhezdinsk ore contains, in addition to silica and alumina, small quantities of barite and gypsum not shown in the analyses; therefore, not all the sulfur in the ore is in the form of pyrite.

The reserves of the Dzhezdinsk deposit are small, about one million tons, with an average manganese content of 30 percent.

Siberian Manganese Ore

In many places in Siberia, as in the Urals, deposits of manganese ore have been discovered which are not sufficiently large to permit exploitation for any length of time. The only exception is the Mazul'sk deposit near Achinsk, which has been supplying manganese ore to the Kuznetsk plant since 1933. The deposit is made up to ten pockets containing ore of dissimilar composition. For this reason, ores arriving at the Kuznetsk plant differ in iron and manganese content and in gangue composition, which makes blast smelting complicated. The chemical composition of two samples of Mazul'sk ore is given in the last two columns of Table 4.

The poorer grade of the Mazul'sk ore is considered average in composition, according to plant analysis. The gangue of the ore is made up of clay; the manganese consists of pyrolusite with an admixture of psilomelane. The iron is brown iron ore.

The analysis of the richer grade is taken from a geological description of the Mazul'sk deposit. In column 5, however, titanium dioxide (0.10 percent) and copper oxide (0.37 percent) are omitted. The plant analysis (column 6) does not show the oxide of barium or the alkali, but it gives a high phosphorus-manganese ratio for Mazul'sk ore, which is three times that of Nikopol' ore. This makes the smelting of spiegel iron from Mazul'sk ore impractical.

The reserves of the Mazul'sk deposits are small. In 1932 they were estimated at 1,250,000 tons and after 10 years of exploitation not more than a 5 years' supply remains.

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